X-ray Fluorescence Microprobes

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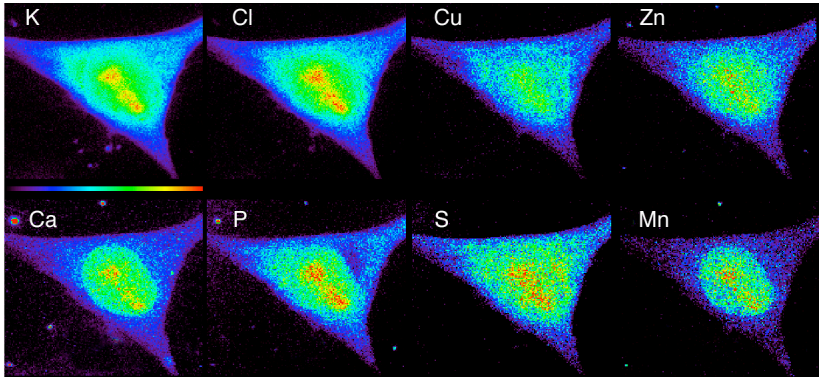
Advanced Photon Source

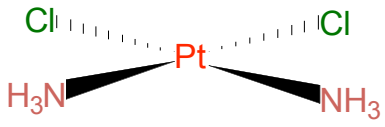
Scientific Need

Submicron microprobes are needed to study trace metals in life sciences:

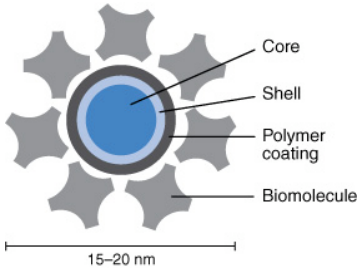
- ***1/3 of all known proteins contain metal cofactors***
- ***Linked to diseases e.g. Alzheimer's, Parkinson's, ALS***
- ***In drugs (Pt-based chemotherapeutic drugs)***
- ***Intracellular labels (Qdots) and tools (nanovectors)***

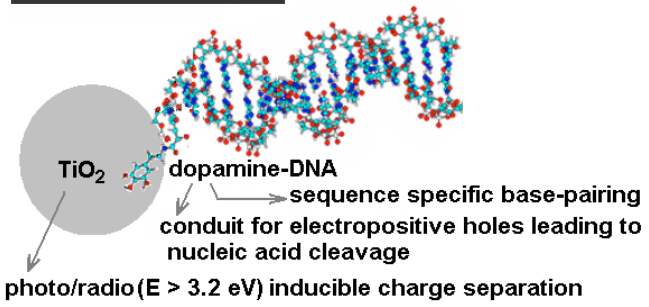


Cisplatin:

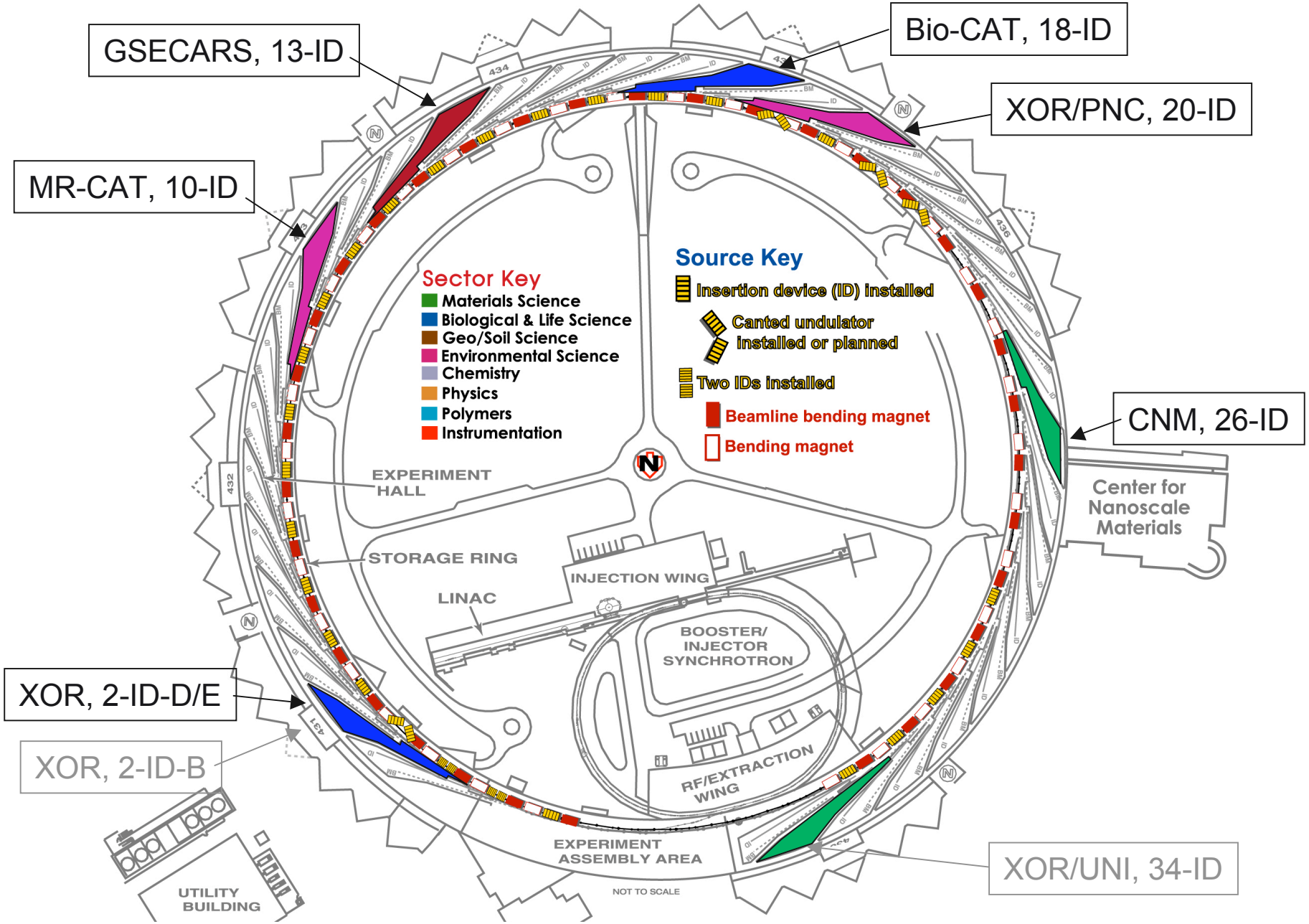


Qdot:





User Demand: XRF Microprobes at the APS



XRF Microprobes at the APS

	Disciplines	Energy	Optics	Resolution	Beamtime
GSECARS 13-ID	Geo/soil/env	4-21 keV	K-B	few μm	30%
PNC/XOR 20-ID	Geo/soil/env	4-27 keV	K-B	few μm	50%
MR-CAT 10-ID	Environ	5-27 keV	K-B	few μm	15%
Bio-CAT 18-ID	Bio/Med	4-13.5 keV	K-B	few μm	25%
XOR 2-ID-B	Soil/Env	1-4 keV	ZP	< 70 nm	20%
XOR 2-ID-D/E	Bio/Med	4-30 keV	ZP	250 nm	90%
CNM 26-ID	nano	3-30 keV	ZP	30 nm	100%

330%

And they are all oversubscribed 2-4x

Current NSLS Programs

X13B – materials science, μ-XRD
mini-gap undulator
white beam or Si(111), 3.8-24 keV
10x3 μm spot size, $5x10^9$ ph/s, K-B or CRL

X-26A – environmental science, μ-XRF, μ-XAFS, μ-XRD
Bending magnet
white beam or Si(111) and Si (311), 4-30 keV,
11x5 μm spot size, $3x10^9$ ph/s, K-B

X-27A – environmental & life science, μ-XRF, μ-XAFS
Bending magnet
white beam or Si(111) and Si (311), 4-30 keV,
15x10 μm spot size, $5x10^9$ ph/s, K-B

Hard X-Ray Microprobes at NSLS-II

- Primary Beamline

  A new XRF microprobe (50-100 nm resolution) for life science applications

  Source: U14 or U19

  Beamline: New, designed for high stability of the focus beam

  Microfocusing optics: K-B or ZP, 10^{11} ph/s into 50 nm spot

  Techniques: μ-XRF, μ-XAFS, XRF tomography

- Secondary Beamlines

  3 x-ray microprobes (micron resolution) for life & environmental science

  Source: DW100 (shared)

  Beamline: upgraded from X13B, X26A, X27A

  Microfocusing optics: K-B, 10^{11}-10^{12} ph/s into 1 μm spot

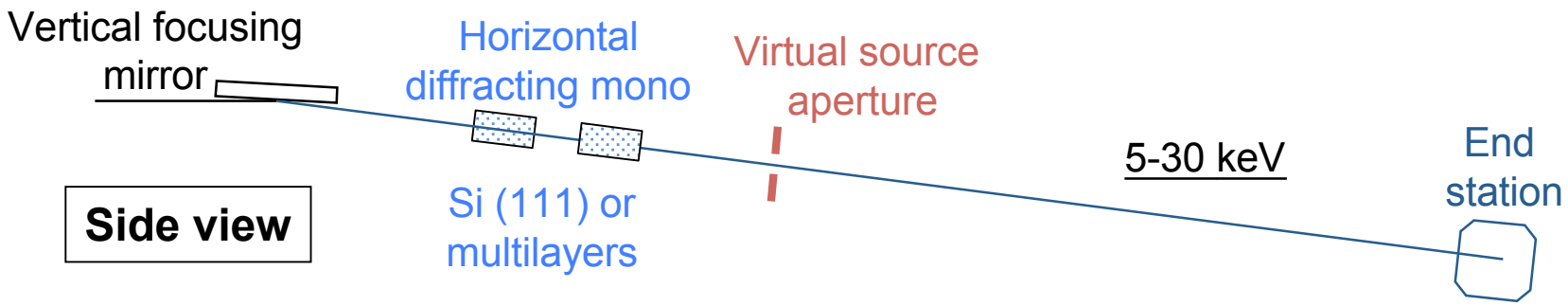
  Techniques: μ-XRF, μ-XAFS, μ-XRD, XRF tomography

New NSLS-II Beamline

Source: U14 or U19, high–β section, brightness ~ $1x10^{21}$ (APS ~ $4x10^{19}$)

Beamline: High beam stability against thermal distortion, vibration, energy scan.

Compatible with higher resolution (down to a few nm)



End station: K-B or ZP optics, 50-100 nm spot size, > 10^{11} ph/s

Cryo-sample environment, vacuum preferable

Single element only collects a few % of 4p! Need multi-element SDD.

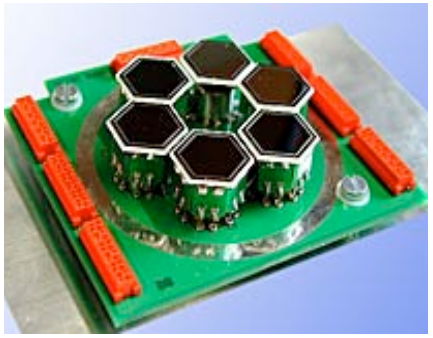
Transition of NSLS X13B, X26A, X27A

Beamline optics: high heat load crystal/multilayers monochromator

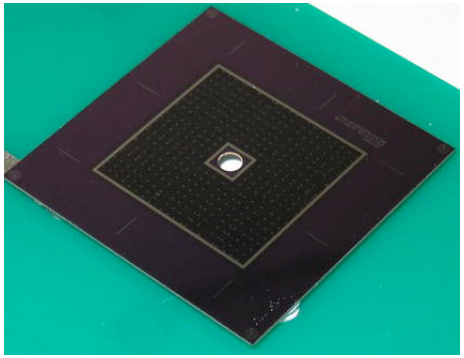
Scanning stages: more precise, closed-loop, able to fly scan

Detector: 100-1000x higher counting rate. Capture > 30% of 4π.

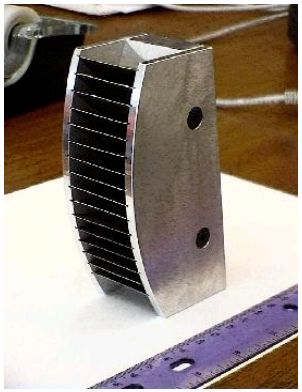
Ketek
6 x100 mm^2

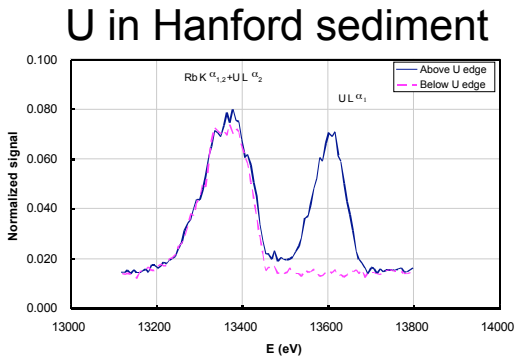


BNL
32 or 96 pixels
1 mm^2 ea.

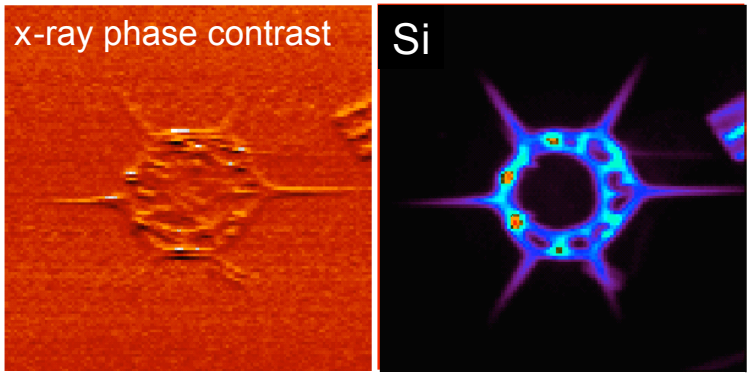


Bent Laue crystals offer medium energy resolution with higher throughout than WDS

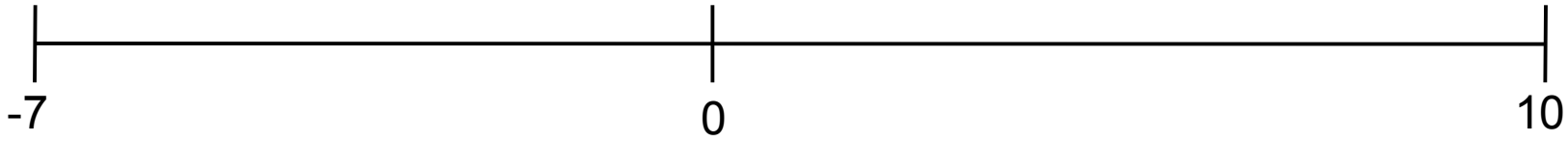




Segmented detector for DPC to correlate with biological structures



Transition Timeline



Discussion?

Laboratory/Office Space for XRF Microprobes

A BSL-2 laboratory with sufficient space for:

- biological workbench
- incubator, centrifuge, refrigerator/freezer
- optical fluorescence microscope, confocal microscope
- plunge-freezer, freeze-dryer, high pressure freezer, cryo microtome, freeze-substitution station
- possibly electron microscope

Office space for staffs, postdocs, students, technicians

Funding

- NIH – NCRR, NIGMS, NIBIB
- NSF – Major Research Instrumentation program
- DOE – BER, BES